

Improving Algorithm Components Related to Ice and Snow for GPM Precipitation Retrievals

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Introduction This project refines algorithm components that can be used for snowfall detection, ice scattering in radiative transfer models, and precipitation retrievals using GPM satellite observations. Specifically, we are working on the following components: (1) snow-rain separation using ground-based observations, (2) database of ice scattering properties and approximation methods for snowflakes, (3) empirical snowfall retrieval guided by radar observations, (4) comparison between modeled and observed microwave brightness temperatures, and (4) snow cloud vs. brightness temperature database for snowfall retrievals over ocean.

Snow-Rain Separation

A snow-rain parameterization is developed using data:
Land: NCEP ADP Operational Global Surface Observations, 1997-2007
Ocean: International Comprehensive Ocean-Atmosphere Data Set (ICOADS), 1995-2007
Upper Air: Integrated Global Radiosonde Archive (IGRA)

Input variables:

- Air temperature (2 m)
- Humidity (2 m)
- Low-level (0 - 500 m) lapse rate
- Surface skin temperature
- Land or ocean

Beyond Sims and Liu (2015), we continue to improve the algorithm by studying the regionally dependence. Also long-term trends of snow/rain fraction is also being investigated.

Scattering Database for Snowflakes

Aggregate snowflakes have been created with their dimension-mass relation constrained by consensus of observations. Their scattering properties have been calculated using DDA and scattering table is archived on the web. With the addition of table to the earlier table for crystal type particles, we now have the scattering table for full range of ice/snow particles, with types of “rounded”, “oblate” and “prolate” aggregates. They are used to study the difference of triple-frequency radar signature between convective and stratiform clouds. In addition to P11, now this table includes other components in the phase matrix.

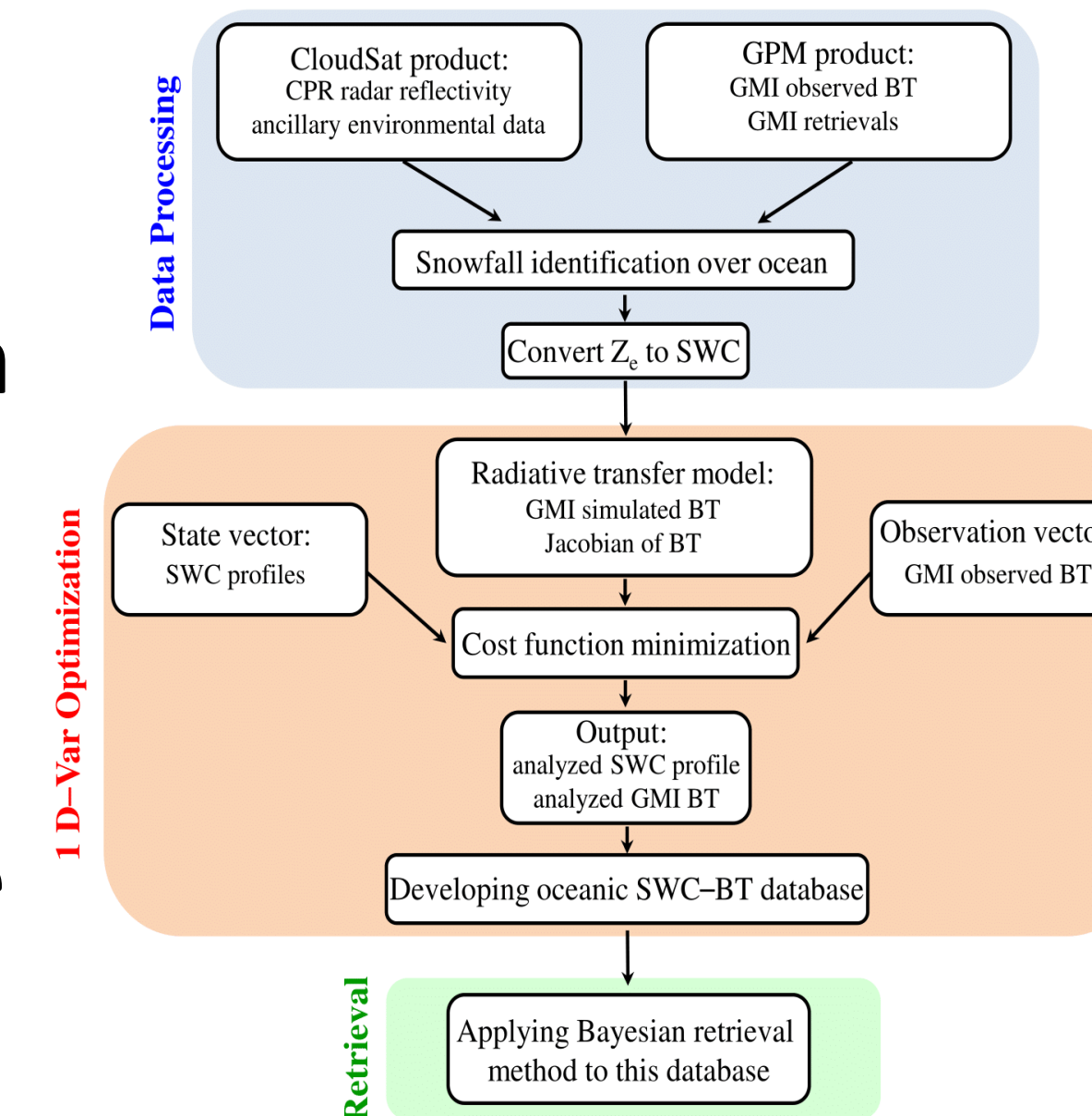
Conclusions

- Improving a pre-screening scheme to separate conditions of snow and rain. Studying long-term variation of the snow vs. rain precipitation frequencies.
- Continuing to the enhance snow scattering table and apply it to study ice microphysics
- Developed an empirical radiometer snowfall retrieval algorithm guided by CloudSat and GPM/DPR radars
Understanding the issues in simulating high-frequency microwave brightness temperatures by RT models
- Developed a snow cloud – T_b database for snow retrieval over ocean

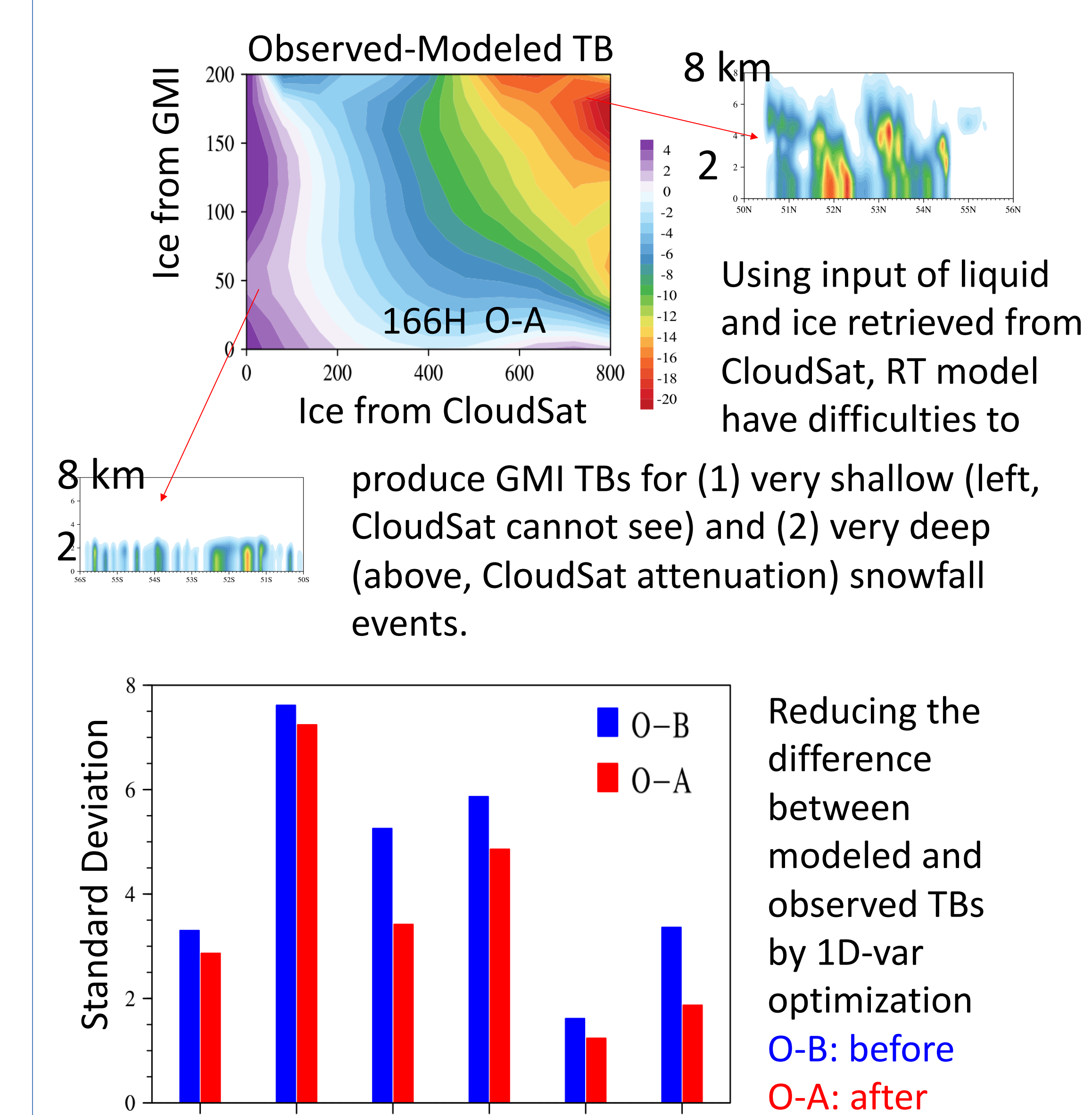
Development of Snow Cloud – Brightness Temperature Database

Approach: Over ocean, surface and atmospheric radiation can be better simulated. We explore the feasibility to build a physically consistent database relating brightness temperatures to snow cloud properties. The approach uses merged CloudSat, GPM, and reanalysis data.

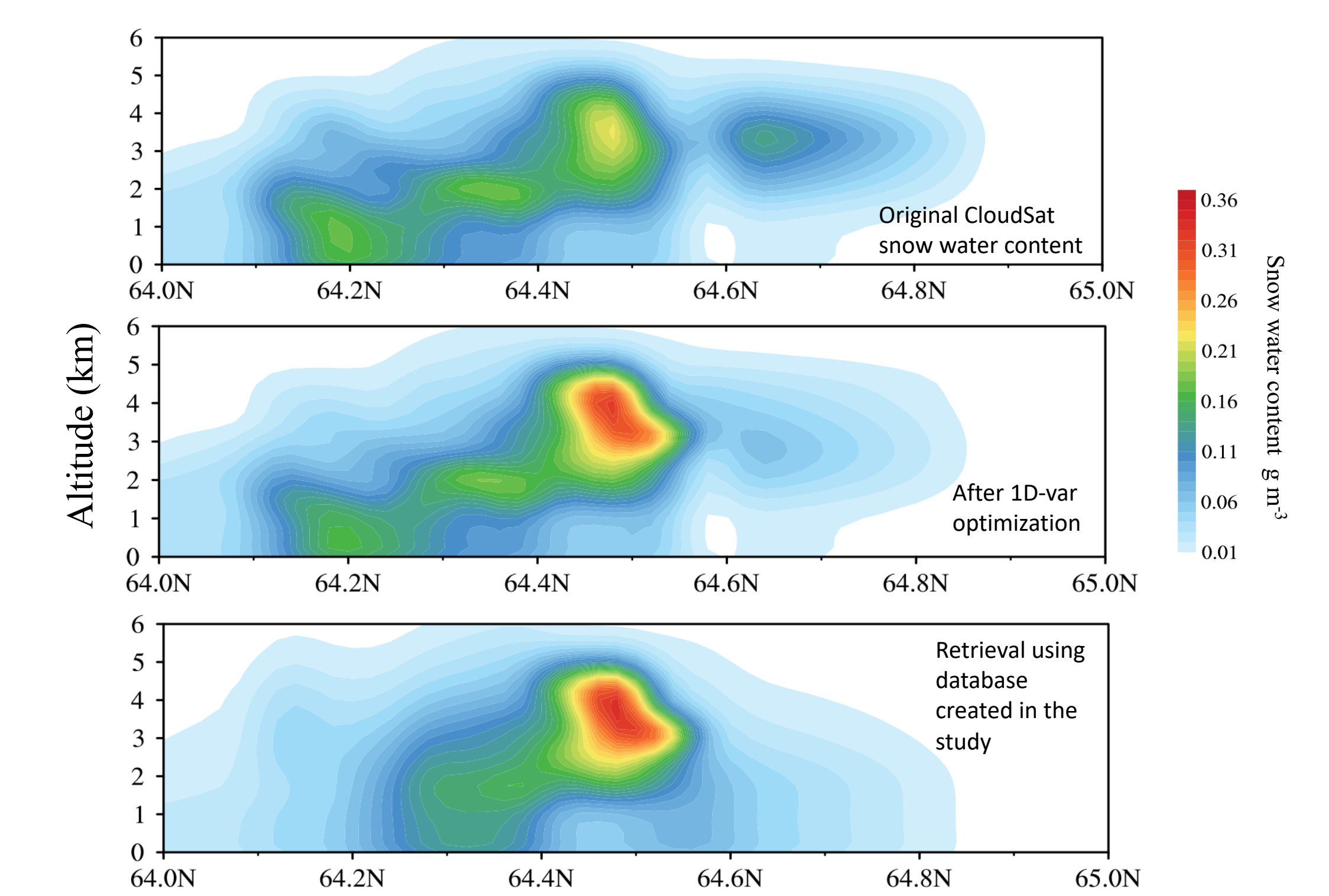
It starts with snow water content (SWC) profiles derived from CloudSat CPR, uses a radiative transfer model and a 1D-Var optimization scheme to obtain a snow cloud properties – GMI TB database, which can be used for SWC/snowfall rate retrievals.



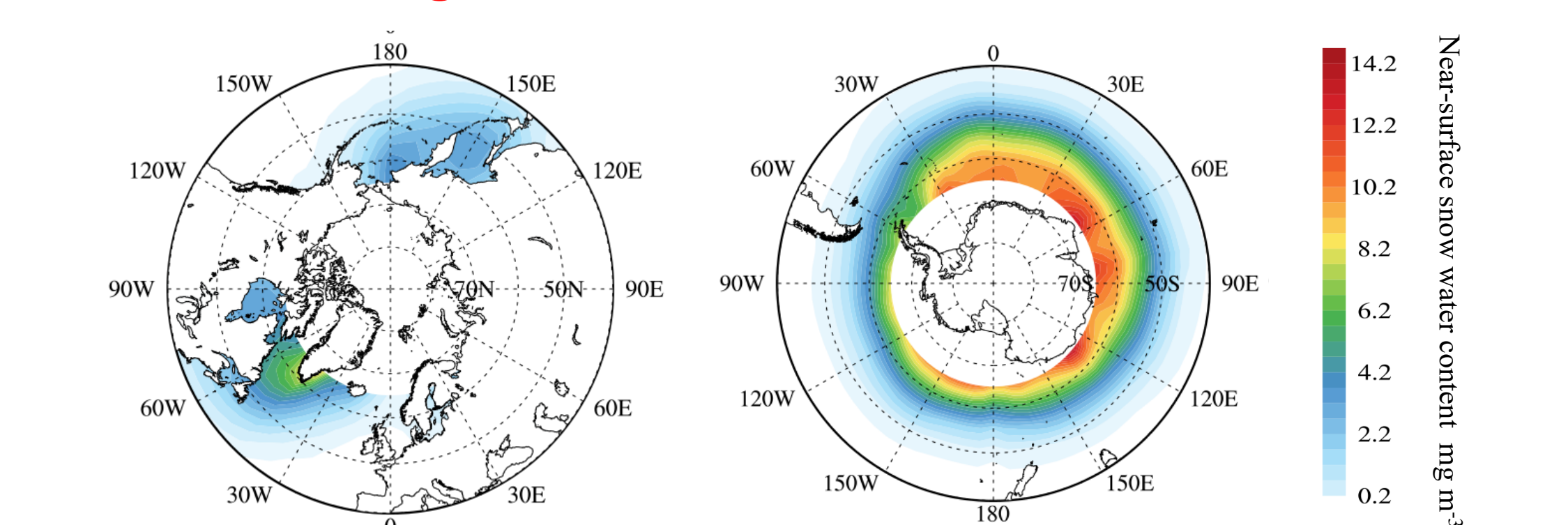
Why optimize the snow-TB pairs are needed?



Case on 12/11/2014

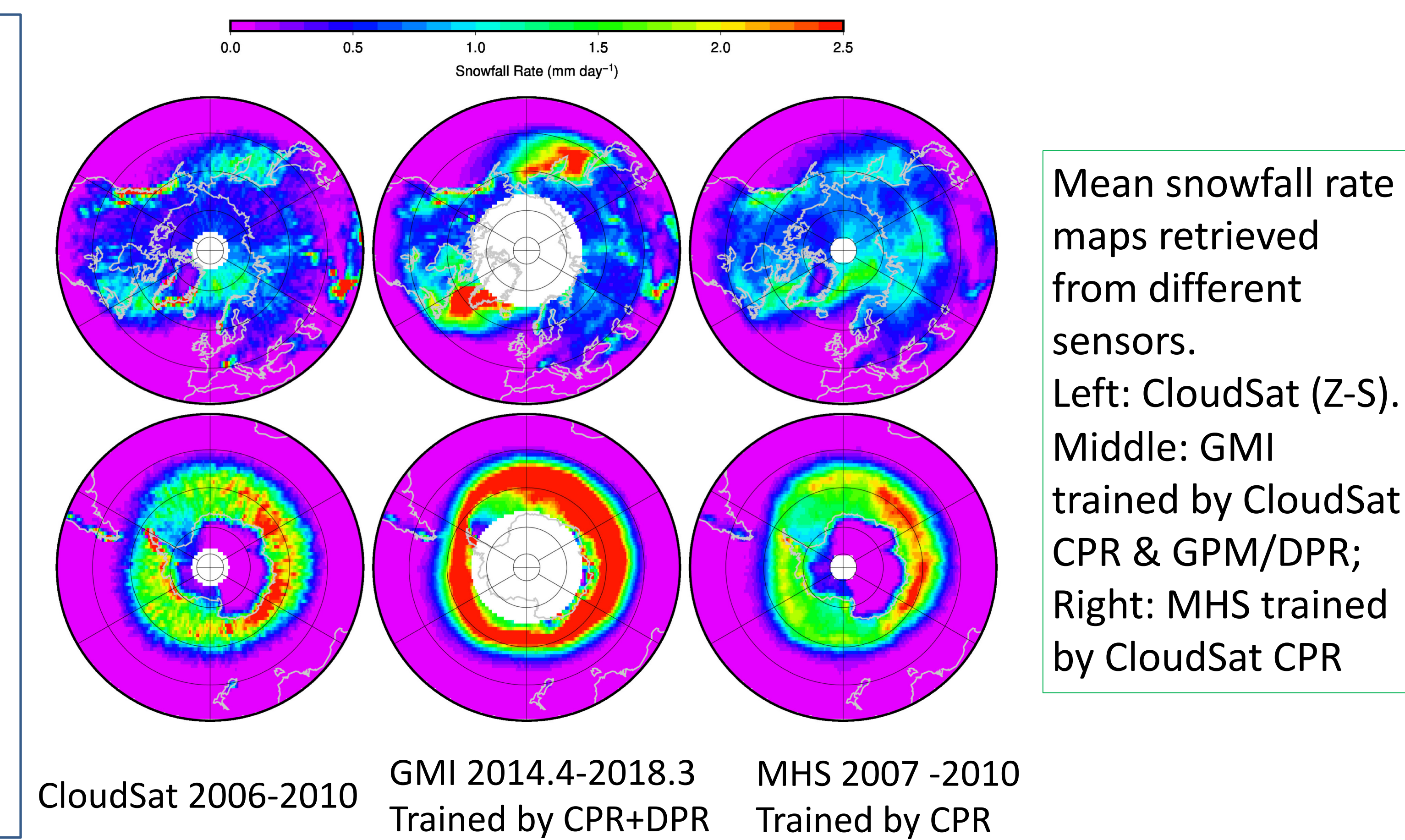


GMI-retrieved global SWC at near-surface level for 2015



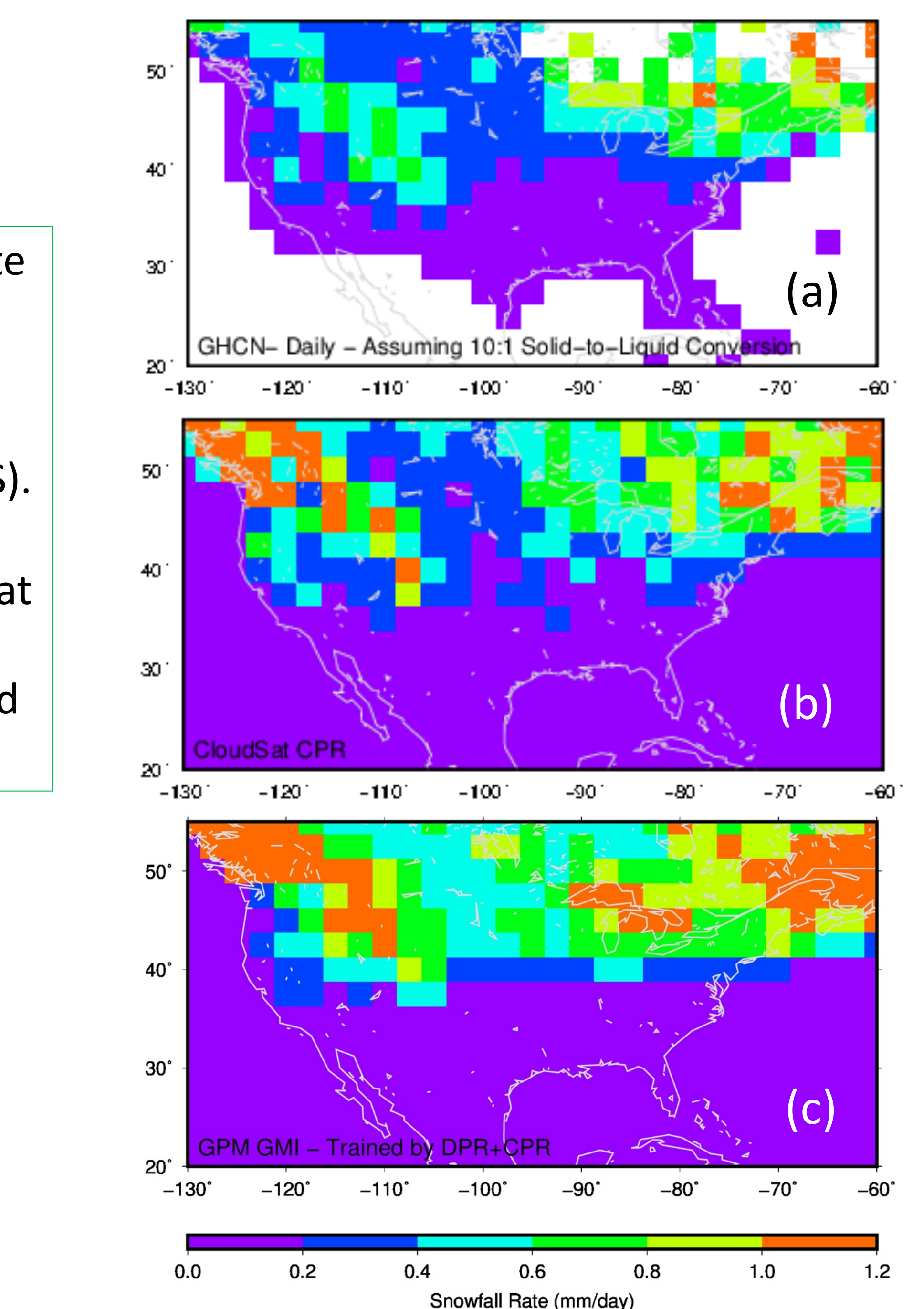
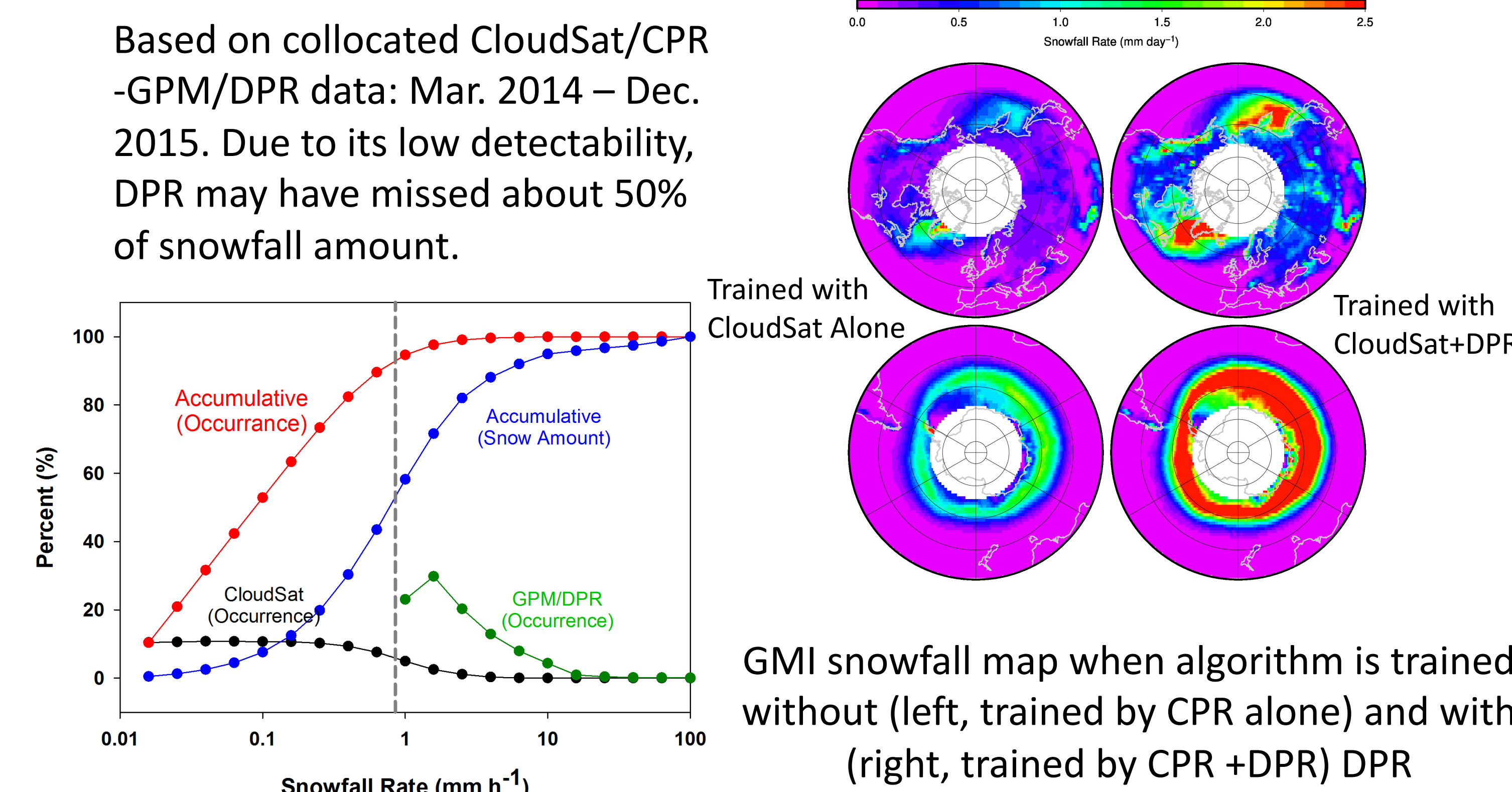
Empirical Snowfall Detection and Retrieval

Method: Over land, snowfall detection/retrieval is based on an empirical algorithm – trained using coincident MW radiometer and radar (DPR+CPR, as truth) data pairs. From radar reflectivity, we first estimate snowfall rate based on modeled nonspherical ice backscattering, then train (high-frequency) passive microwave observations in 3D brightness temperature EOF-space to give snowfall probability and snowfall rate (Seo and Liu, 2013)



Use combined CloudSat/CPR vs. GPM/DPR as “truth”:

DPR (Ku or Ka) has a minimum detection of about 13 dBZ, missing most of snowfall events, while CloudSat CPR has clear attenuations for heavy snowfall. Combined DPR-CPR data are used as “truth” in the GPM GMI empirical algorithm. Z-S relations for DPR/CPR are derived from nonspherical ice scattering database with assumed size distributions.



- (a) GHCND + Canada Station observed climatology – multiple years
- (b) CloudSat – near surface, 2006 – 2010.
- (c) GMI – 2014.4-2018.3, trained by CloudSat/CPR + GPM/DPR
 - Similar pattern – therefore, GMI retrievals catch the horizontal pattern of snowfall
 - Different magnitude – need more study for “truth” data, Z (radar) to S (snowfall) conversion.